Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
Allocation and Service Rules for the 1675-1680 MHz Band	)	WT Docket No. 19-116 RM-11681
To: The Commission	)	

REPLY COMMENTS OF LIGADO NETWORKS LLC

Gerard J. Waldron
Ani Gevorkian
COVINGTON & BURLING LLP
One CityCenter
850 Tenth Street, NW
Washington, DC 20001
(202) 662-6000

Counsel for Ligado Networks LLC

July 22, 2019

Table of Contents

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
Allocation and Service Rules for the 1675-1680 MHz Band	)	WT Docket No. 19-116 RM-11681
To: The Commission	)	

REPLY COMMENTS OF LIGADO NETWORKS LLC

I. INTRODUCTION AND EXECUTIVE SUMMARY

As the Commission considers the future of the 1675-1680 MHz band, it must bear in mind the overarching stakes at issue in this proceeding: the 1675-1680 MHz band is primed to help the United States make 5G service a reality—and thereby unlock the massive benefits that 5G promises. The Commission should move ahead promptly in this proceeding to help capture that opportunity. The record shows that reallocating the 1675-1680 MHz band for shared commercial use can accelerate the nation's transition to advanced 5G services while also protecting existing federal users and ensuring all Americans can access NOAA's weather data.

There has been much rhetoric in the docket, but that apparently is an attempt to muddy what is otherwise clear: the 14 locations identified in the Commission's proposed rule will protect federal users, and those users are the only entities entitled to protection. The evidence that the protection zones will meet the needs of federal users comes from a million-dollar study by Alion Science and Technology ("Alion"), a study in which NOAA was deeply involved from

the beginning and essentially managed. So to those who are arguing that more study is needed, the Alion study, completed at the direction of NOAA, provides the Commission with all the information NOAA and the Commission need to move forward. As for those non-federal entities that have been listening in on this band, they have no legal right to protections since they have no status under the Commission's rules and are not recognized in Part 2 or note US88 in the U.S. Table of Allocations ("U.S. Table"). Notwithstanding their lack of standing, the Commission has proposed a content delivery system ("CDS") to provide these entities—and all Americans—with an effective means of continuing to access the federal data available on the band. The record shows that the proposed CDS serves as an effective alternate means of accessing the federal data, and if NOAA were actually to cooperate in operating the CDS, the CDS should be superior to satellite redistribution.

The Presidential Budget imposes a fiscal year 2020 deadline for completing the auction of this band. To meet that deadline, the Commission must bring this proceeding to a close by the end of this year or no later than early next year, given the steps required to complete an auction in that timeframe. The Commission should therefore not be distracted and should instead remain focused on the real issue: moving our nation forward toward a 5G reality and realizing the billions in economic benefits that await.

II. REALLOCATION OF THE 1675-1680 MHZ BAND TO SHARED COMMERCIAL USE WILL FACILITATE THE 5G TRANSITION AND THEREBY GENERATE SUBSTANTIAL PUBLIC INTEREST BENEFITS.

The Commission adopted this NPRM in recognition of the national imperative to free up spectrum to facilitate the transition to 5G.[1] While 5G service as a whole promises enormous

[1] *See In the Matter of Allocation and Service Rules for the 1675-1680 MHz Band, Notice of Proposed Rulemaking,* WT Docket No. 19-116 (rel. May 13, 2019) (hereinafter "*NPRM*").

benefits,[2] the potential in this five megahertz band alone is noteworthy. As the attached report from The Brattle Group explains, this small block of spectrum could generate over $10 billion in benefits to the economy.[3]

The Brattle Group Report reviews the value of existing spectrum to understand the potentially far-reaching impact of this block. Measured in 2015, the value of the existing 645.5 megahertz of licensed spectrum available for the mobile wireless industry totaled approximately $500 billion. The indirect impact of that spectrum, as measured through a multiplier analysis, implied that it could generate between $5 trillion and $10 trillion in consumer surplus, a 10 to 20 times multiple of its direct value.[4] Because the five megahertz at 1675-1680 MHz is valued at approximately $600 million, past experience indicates it can generate a consumer surplus of an additional *$6 to $12 billion* for the economy.[5]

Some commenters in this proceeding have noted the potential for lost economic value if the band is reallocated to shared use. These claims are unsubstantiated and may be speculative, but for argument's sake, we will consider them. Lockheed Martin notes that its investment to date in satellite hardware and software to support GOES Rebroadcast ("GRB") is over $10 million per spacecraft.[6] AccuWeather stated that the installation of its earth stations resulted in

---

[2] Some estimates project 5G will produce more than $12 trillion in global economic output by 2035. When the entire 5G value chain is considered, estimates project the benefits will top $3.5 trillion and support 22 million jobs. *See* Bruce Mehlman, *Why the 5G Race Matters*, The Hill (Dec. 10, 2018), *available at* https://thehill.com/blogs/congress-blog/technology/420509-why-the-5g-race-matters.

[3] *See* Attachment A, Coleman Bazelon, The Brattle Group, *Advancing 5G Deployment: Shared Flexible Use of the 1675 – 1680 MHz Band* (July 22, 2019), at 7 (internal citations omitted) (hereinafter "Brattle Group Report").

[4] *See id.*

[5] *See id.*

[6] *See* Comments of Lockheed Martin, WT Docket No. 19-116 (June 21, 2019), at 2.

millions of dollars of investment.[7] And the Space Science and Engineering Center ("SSEC") at the University of Wisconsin-Madison indicates that replacement costs for GRB antennas, the cost of the land where the antenna will be sited, site preparation, and internet connectivity fees could amount to hundreds of thousands of dollars.[8]

These arguments fail basic economic analysis. *First*, the value these investments were meant to generate will not actually be lost. These non-federal entities have made good on their investments by using the satellite equipment they purchased over the years to gain access to the data, and in AccuWeather's case, built an entire revenue-generating business based on the NOAA data they were gathering for free. In addition, Lockheed has already received substantial payments for its work for NOAA.[9] More fundamentally, however, once the band is reallocated for shared commercial use, these entities *can continue their pursuits*: NOAA's weather program will continue, and a CDS will deliver the same NOAA data that these entities have been gathering. Thus, these entities will remain fully capable of pursuing the underlying purpose for which they made the investments: generating their own services based on the NOAA data. The key element that will change is that, following the completion of the auction that is the subject of this NPRM, no other entities will need to make the same level of investment, since the CDS will make the NOAA data available to everyone.

[7] *See* Comments of AccuWeather, WT Docket No. 19-116 (June 21, 2019), at 10-11 (hereinafter "AccuWeather Comments").

[8] *See* Comments of Space Science and Engineering Center, WT Docket No. 19-116 (June 21, 2019), at 2.

[9] *See, e.g.*, Dan Leone, *Lockheed Martin Tapped for 2 More GOES Satellites*, Spacenews (May 1, 2013), *available at* https://spacenews.com/35338lockheed-martin-tapped-for-2-more-goes-satellites/.

Second, even if these commenters' claims of "lost value" were true, the loss would pale in comparison to the value that reallocation will provide. The estimates these parties themselves provide reveal that the comparison of value is markedly lopsided. The economic benefits of reallocation will be at least three orders of magnitude higher than the so-called costs.[10] The implication of this comparison is unequivocal: the Commission can facilitate far more economic growth by reallocating this band for shared commercial use. The Commission should not let self-interested narrow financial concerns from a handful of entities[11] preclude this opportunity.

Third, the fact that these entities have been making use of a service provided for free by the government for years does not give them a legal or equitable claim to continue to free ride exactly how they want in perpetuity. The CDS proposed by the Commission will give them access to the NOAA data and will have the additional public interest benefit of making the data available to anyone with an Internet connection.

In sum, this five megahertz of spectrum can be coupled with other available bands, including the adjacent 1670-1675 MHz band as well as other bands that are the subject of Ligado's pending modification applications, to make available a broad swath of 40 megahertz of critical lower mid-band spectrum that will facilitate the transition to 5G.[12] The Commission

---

[10] *See Brattle Group Report* at 7.

[11] With its suggestion that the 1.6 GHz licensee(s) should "bear the costs of any additional compliance or monitoring obligations and operational burdens imposed on AWS-3 licensees or federal operators," SNR Wireless is likewise seeking to protect its own narrow financial interests, and Commission should interpret its comments accordingly. *See* Comments of SNR Wireless LicenseCo, LLC, WT Docket No. 19-116 (June 21, 2019), at 1 (hereinafter "SNR Comments").

[12] As Ligado explained in its initial Comments, this five megahertz of spectrum, assuming Ligado would prevail at auction, could be combined with the 1670-1675 MHz band, which Ligado already has access to, to create a ten megahertz block that then could be used as a 10 MHz downlink which would be added to the spectrum Ligado has at 1526-1536 MHz, 1627-1637 MHz, and 1646-1656 MHz to create 40 megahertz of "green-field" lower mid-band

should therefore align the rules for this five megahertz band to reflect the role it can play in a larger spectrum plan and thereby unleash the band's full potential.

III. ALL USERS OF THE 1675-1680 MHZ BAND WILL RECEIVE ADEQUATE PROTECTION.

The Commission can move forward in pursing these tremendous public benefits because all existing users in this band—both federal and non-federal—will remain protected. None of the comments submitted provide any meaningful grounds to doubt this conclusion.

A. The Record Shows That Federal Users Will Be Protected.

As Ligado explained in its initial Comments, the federal users who are legally entitled to protection from harmful interference will receive such protection through the establishment of the 14 protection zones identified in note US88 of the U.S. Table.[13] The Commission has correctly identified protection zones as the appropriate way to ensure that these earth stations can continue to function without disruption. No commenters contested the list of 14 federal locations in note US88.[14]

---

spectrum. *See* Comments of Ligado Networks LLC, WT Docket No. 19-116 (June 21, 2019), at 13-14 (hereinafter "Ligado Comments"). More lower mid-band spectrum for 5G has been identified as an important step to a successful transition to 5G. *See id.* at 1-4. As also noted in the Comments, Ligado can only be expected to participate robustly in an auction for 1675-1680 MHz if the pending license modifications for those other bands are approved. *See id.* at 3.

[13] *See NPRM* at Appendix A, § 27.1410(a). *See also* 47 C.F.R. § 2.106.

[14] Commenters only addressed sites missing from the list set forth in paragraph 8 of the NPRM, which does not purport to track note US88. *See* Comments of National Spectrum Management Association, WT Docket No. 19-116 (June 21, 2019), at 7 (hereinafter "National Spectrum Management Association Comments"); Letter from Users and Stakeholders of Weather and Water Information and Technology to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 19-116 (May 2, 2019), at 2; Comments of OTT Hydromet Corporation, WT Docket No. 19-116 (June 21, 2019), at 2 (hereinafter "OTT Hydromet Corporation Comments").

The record clearly shows that the protection zones will in fact protect these 14 sites. That conclusion comes from a comprehensive engineering study conducted by Alion,[15] an organization that was engaged for this project based on NOAA's recommendation.[16] The purpose of the Alion study was to determine the feasibility of a commercial wireless operator sharing the 1675-1680 MHz band with NOAA and the technical and operational parameters under which such operation could occur—*precisely the issues that are relevant to this proceeding.*

We are confident NOAA is well aware of the Alion study's conclusions given that NOAA was closely involved in every step of preparing for, conducting, and reviewing the study. As explained in detail in the attached declaration by Ligado consultant Geoffrey Stearn,

- NOAA recommended that Alion be hired to conduct the study, based at least in part on previous work that Alion had performed related to GOES-R;
- NOAA participated in drafting the Statement of Work and joined the planning calls;
- NOAA headquarters in Silver Spring, Maryland is where many of the meetings took place about the project; and
- NOAA provided a considerable amount of direction and data to Alion throughout the course of the study as well as input on the draft reports that Alion produced.[17]

[15] *See* Alion Science and Technology, *Assessment of the Potential for LightSquared Broadband Base Stations in the 1670-1680 MHz Band To Interfere with Select NOAA Legacy Ground Locations* (Feb. 2014) (hereinafter "Alion Report"), *filed as attachment to* Letter from Jeff Carlisle, Executive Vice President for Regulatory Affairs and Public Policy, LightSquared Subsidiary LLC, to Marlene H. Dortch, Secretary, Federal Communications Commission, RM-11681; IB Docket No. 12-340; IBFS File Nos. SAT-MOD-20120928-00160, SAT-MOD-201220928-00161, SES-MOD-20121001-00872 (Apr. 14, 2014) (hereinafter "LightSquared April 14, 2014 Letter").

[16] *See* Attachment B, Declaration of Geoff Stearn, at 2.

[17] *See id.*

Moreover, the Alion study was quite comprehensive. Given that NOAA was closely involved in drafting the Statement of Work, it is not surprising that the Alion study covered many topics important to NOAA, including:

- identifying lists of Federal GOES sites and their characteristics;
- using inputs from NOAA to develop RF link level protection requirements including anomalous propagation;
- RFI analysis including strong signal analysis and Frequency Dependent Rejection beftween bands of study; and
- LTE FDD signal characterization.[18]

Thus, the Alion study, which was overseen by NOAA, provides the Commission with the vital information it needs to conclude that GOES-R can be protected against interference from shared commercial use of 1675-1680 MHz through the creation of protection and coordination zones. With the Alion study in the record, the Commission can move forward with this proceeding knowing NOAA's input on the technical matters relevant to reallocation is already in the record. As a result, allocating the 1675-1680 MHz band for shared commercial use will not result in any loss related to federal entities' use of the band.

B. The Entities That Listen In On 1675-1680 MHz Are Not Entitled To Protection, and the NPRM Correctly Recognized This.

Some non-federal entities filed comments complaining that the NPRM erred in not extending the same protection, *i.e.*, protection zones, to the non-federal entities listening in on the band, but they all fail to address one inconvenient fact: these entities have *no legal status* in relation to the 1675-1680 MHz band. Nor does their past or current use of the band entitle them to any such status in the future. Accordingly, the NPRM correctly concluded that these entities

[18] *See* Alion Report at 17, 19, 22, 27, 90, 94-65.

are not entitled to any protections in this band—much less to the same level of protection federal users receive, as some commenters have suggested.[19]

Non-federal entities lack legal status because they are neither licensees nor registrants—the two types of entities that the Commission has indicated in past proceedings may be afforded protection from harmful interference in a band.[20] The 1675-1680 MHz band is licensed to NOAA, and while the Commission extended protections once reserved for licensees to registrants in the course of the C-Band proceeding,[21] no such FCC registration program exists for non-federal receive-only earth stations in the 1675-1680 MHz band (and, for the reasons discussed below, would be inappropriate). As a result, unlike the receive-only Earth stations that use the C-Band, the non-Government entities at issue here lack legal status and are not entitled to the protections they seek in the 1675-1680 MHz band.

The fact that these entities have been listening in on the band does not confer any legal status or entitlement to protections going forward. First, a registration program is not appropriate in this proceeding because the underlying dynamics in the C-Band and the 1675-1680 MHz band are fundamentally different. In the C-Band, the receive-only earth stations are the intended

---

[19] *See e.g.*, AccuWeather Comments at 5; AWCIA Comments at 7; Comments of Microcom, WT Docket No. 19-116 (June 21, 2019), at 8; Comments of American Geophysical Union, American Meteorological Society, National Weather Association, WT Docket No. 19-116 (June 21, 2019), at 2-3 (hereinafter "AGU *et al.* Comments"); Comments of National Hydrologic Warning Council, WT Docket No. 19-116 (June 21, 2019), at 1 (hereinafter "National Hydrologic Warning Council Comments"); Comments of ALERT Users Group, WT Docket No. 19-116 (June 21, 2019), at 2 (hereinafter "ALERT Users Group Comments"); Comments of Harris County Office of Homeland Security & Emergency Management, WT Docket No. 19-116 (June 21, 2019), at 2 (hereinafter "Harris County Comments").

[20] *See Public Notice, International Bureau and Wireless Telecommunications Bureau Seek Focused Additional Comment in 3.7-4.2 GHz Band Proceeding*, GN Docket No. 18-122, RM-11791, RM-11778 (rel. May 3, 2019).

[21] *See id.* at 6, *citing Amendment of Part 25 Order*, at 2807, ¶ 7.

recipients of the space station transmissions.[22] The C-Band satellite companies were given authority to operate a space station, and the earth stations (their customers) close the link and justify the space station license. In the 1675-1680 MHz band, NOAA was given authority to operate a space station, and the 14 locations identified in the U.S. Table of Allocations close the link and justify the space station license. The non-federal receive-only stations are simply eavesdroppers. The Notice of Proposed Rulemaking thus reached the correct conclusion: the sites entitled to protection zones—the intended recipients—are the 14 locations listed in note US88 of the U.S. Table.[23] The non-federal entities here are at best collateral beneficiaries of the satellite transmissions to the 14 locations identified in the Commission's rules, but their use of the transmissions in this band is not why the Commission licensed the band to NOAA; if they were, these entities would be identified in note US88. Accordingly, the registration process underway in the C-Band proceeding would not be appropriate given the legal considerations at issue here, and this proceeding need not be complicated by suggestions to the contrary.

Furthermore, non-federal entities' use of this band does not bestow them with any rights they lacked to begin with—their suggestions of a reliance interest notwithstanding. Indeed, courts have made clear that *no reliance interest exists* where parties invested in the absence of legal right.[24] The reasoning behind this principle is clear: were the Commission to recognize a legal interest affording non-federal entities protection in this band, the Commission would be

---

[22] *See e.g.*, *In the Matter of Expanding Flexible Use of the 3.7 to 4.2 GHz Band*, No. GN18-122, 2018 WL 3435167, at *4 (OHMSV July 13, 2018). Furthermore, as Google explained in that proceeding, the rights of a space station operator are to transmit and successfully connect to FCC-authorized earth stations. This does not imply unconditional protection of earth stations, and the legal status of earth station operators is dependent on the rights of space station operators to successfully connect. *See* Comments of Google, GN Docket No. 18-122, RM-11791, RM-11778 (filed July 3, 2019), at 4.

[23] *See NPRM* at Appendix A, § 27.1410(a).

[24] *See e.g.*, 47 U.S.C. § 301; *Cassell v. FCC*, 154 F.3d 478, 486 (D.C. Cir. 1998).

setting potentially sweeping precedent, holding that any entity listening in on a band to which it has no legal right can nevertheless obtain protection in that band for all time simply because it has been listening in on that band. Pleas that effectively amount to an adverse possession claim on spectrum have no place in Commission rulemakings and no value here.

Moreover, granting non-federal entities the same level of protection as federal entities receive would dramatically diminish the value of the 1675-1680 MHz band.[25] The Commission has acknowledged that when it considers rules that should govern potential interference, the "Commission must consider the public interest benefits associated with potential uses . . . including, but not limited to, the net effect on the economic values"[26] of the band. As explained in the Brattle Group Report, the fragmentation of the band that would result from expanding the number of protection zones from the 14 identified in the U.S. Table to upward of 100 would dramatically reduce the geographic areas where the spectrum could be utilized while simultaneously increasing the coordination costs required to deploy the spectrum around the exclusion zones.[27] The lost benefits from these proposals would be measured in the billions.[28] There would be little point left in the Commission even bothering to reallocate this band if doing so entailed providing protection zones to all non-federal entities—a protection to which such entities are not even entitled in the first instance.

IV. OPPONENTS PRESENT NO VALID TECHNICAL REASONS TO PREVENT MAKING THIS SPECTRUM AVAILABLE FOR 5G.

[25] *See, e.g.*, *In the Matter of Amendment of the Commission's Rules with Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, & 2155-2180 MHz Bands*, 29 FCC Rcd. 4610-11, 4684 (2014).

[26] *In the Matter of Serv. Rules for Advanced Wireless Servs. in the 2000-2020 MHz & 2180-2200 MHz Bands*, 27 FCC Rcd. 16102, 16128 (2012).

[27] *See Brattle Group Report* at 12.

[28] *See id.*

In an attempt to make the issues at stake in this proceeding appear more complex and difficult than they are, certain commenters have raised concerns regarding the technical feasibility of sharing this band. In particular, commenters have criticized the idea that a CDS can afford them continued access to NOAA's data and raised issues related to latency, reliability, the proposed power levels and band plan, emergency communications systems, and alternate bands for delivery of the NOAA data. They have also suggested that the Commission cannot proceed with reallocation until NOAA has concluded its ongoing study. On all these subjects, the commenters' claims are flawed.

Before turning to the specific issues, however, it is important to emphasize that Ligado has long held the view that NOAA is quite sophisticated at distributing its data via various forms, including through the cloud and terrestrially,[29] and that it could presumably design a similar solution here. In the absence of NOAA stepping forward with any constructive ideas, Ligado has suggested a CDS and has built a prototype system. However, we are confident that NOAA could dramatically improve this system by cooperating with the CDS and, for instance, allowing the CDS to interconnect at its uplink facility—thereby saving the data a round-trip to space and instead instantly sending it along a terrestrial fiber system at the speed of light. So a productive discussion could be had if NOAA were to constructively engage in how best to design a system to distribute that data and to work with the auction winner of 1675-1680 MHz. Frankly, if

[29] Ligado has previously noted that NOAA worked with Amazon Web Services ("AWS") (the host of Ligado's CDS), Google Cloud Platform, IBM, Microsoft, and the Open Commons Consortium ("OCC") to develop a way to store and process NOAA data and to make it available to more users. *See* Letter from Gerard J. Waldron, Counsel, Ligado Networks, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 19-116 (June 13, 2019) *citing* Edward J. Kearns (NOAA Chief Data Officer), *NOAA's Big Data Project* (Apr. 20, 2018), at 17-20, https://www.cmts.gov/downloads/CMTS_Webinar_Speaker_Kearns_20Apr2018.pdf.

Ligado is the high bidder, it fully expects that result, since it is the only logical way to proceed. But because NOAA has refused to engage on a CDS discussion, despite numerous efforts by the company, the Commission rightly put out the CDS option in the NPRM.

Moreover, Ligado's proposed CDS is not the only possible form a CDS could take. Ligado would gladly work in cooperation with other entities to refine its existing proposal or develop a new proposal. Particularly since the Commission acknowledges that other possibilities for delivering the NOAA data to non-federal entities may exist,[30] it should bear in mind that the options before it do not reduce simply to accepting Ligado's proposed CDS or not reallocating the band at all; technology offers many solutions for achieving spectral efficiency, and the 5G benefits that reallocation would provide require that all entities work together in good faith to explore these solutions and implement the most promising option. For the reasons explained below, Ligado believes a CDS—and specifically, its proposed CDS—can achieve the objectives the Commission outlines in the NPRM.

A. Latency

Some commenters have claimed that the latency of a CDS will be inadequate as compared to that of GOES-R satellite downlink transmission. AccuWeather offers an assessment of purported "material" latency differences between the GOES-R downlink and Ligado's existing CDS service, which is currently providing data to George Mason University ("GMU").[31] Specifically, AccuWeather contends that GMU's system monitoring indicates

[30] *See NPRM* at ¶¶ 19-20.

[31] *See* Letter from Gerard J. Waldron, Counsel, Ligado Networks LLC to Marlene Dortch, Secretary, Federal Communications Commission, WT Docket 19-116 (June 13, 2019) (hereinafter "Ligado June 13, 2019 *Ex Parte*").

satellite radiance data (data used to make images) received via the CDN has a latency of 20 to 80 seconds, whereas data received via GRB has a lower latency of 2 to 15 seconds.[32]

This comparison is misleading and invalid. AccuWeather's GRB latency numbers reflect the speed of delivering *unprocessed* data from the GOES-R satellite—but the numbers AccuWeather choses to include for the Ligado CDS reflect the speed of delivering *processed* data to GMU. Of course, the latency for delivering processed data will be higher than the latency for delivering unprocessed data due to the time processing data necessarily takes. AccuWeather is therefore comparing apples to oranges. As illustrated in the slides in Attachment C, an accurate comparison—*i.e.*, a comparison for the delivery of unprocessed data only—reveals that Ligado's CDS estimated latency added, in total, 99 milliseconds, or just one-tenth of 1 second. AccuWeather insists that, "[s]econds, let alone minutes, lost during high impact weather events is simply unacceptable and poses serious public danger."[33] If that's right, then using the proposed CDS, not even a single second will be lost, and users will experience no impact.

Other commenters contend that NOAA's return on its investment in the GOES satellite service is jeopardized by the band's reallocation. That claim, too, does not withstand scrutiny. AccuWeather and the American Weather and Climate Industry Association ("AWCIA") claim that one of the ways that NOAA receives significant return on investment from the GOES-R series of satellites is through "American Weather Enterprise" users who access the data with satellite downlinks and incorporate the data into their own products and services.[34] If that is in

[32] *See* AccuWeather Comments at 14-15.

[33] AccuWeather Comments at 15.

[34] *See id.* at 16; Comments of American Weather and Climate Industry Association, WT Docket No. 19-116 (June 21, 2019), at 7 (hereinafter "AWCIA Comments"), at 5.

fact the case, then NOAA and others should embrace an effort to make the NOAA data more broadly available, since that should grow the enterprise.

AccuWeather further claims that the latency differential will result in some loss of this investment if "organizations lose access to data via GRB."[35] This sets up a strawman because no one contends organizations should lose access to GRB data. But if AccuWeather's point is really about latency, then any purported loss of value from such a difference is, in fact, illusory, since no measurable impact on latency will occur. Indeed, because the CDS is an effective substitute for distributing the NOAA data, AccuWeather, AWCIA, and other non-federal users will be able to get the same data they are currently using for their own services—still free of cost to them—so that they can continue to provide the services they currently provide. If anything, NOAA's return on investment will *increase*, given that the CDS will make the NOAA data more broadly available and also can provide more robust and manageable data compared to satellite rebroadcast that is bandwidth limited.

B. Reliability

Commenters also assert that the proposed CDS will be less reliable than a satellite delivery system. In particular, commenters appear to raise concerns about reliability both with respect to a CDS's ability to deliver data packets[36] and with respect to the susceptibility of a CDS's physical infrastructure to disturbance during a severe weather event.[37] These concerns are unconvincing.

---

[35] AccuWeather Comments at 16.

[36] *See, e.g.,* AccuWeather Comments at 11; ALERT Users Group Comments at 3.

[37] *See, e.g.*, Comments of Boeing, WT Docket No. 19-116 (June 21, 2019), at 3-4; AccuWeather Comments at 6; Comments of Interstate Council on Water Policy, WT Docket No. 19-116 (June 21, 2019), at 2.

The record already contains extensive evidence regarding the reliability of data packet delivery.[38] Specifically, Ligado has explained that in the more than two years that Ligado's CDS has been operational, it has delivered over 292 million files with *zero delivery errors.*[39] Ligado has further explained that numerous national telecommunications providers offer internet service with availability that is comparable or superior to the 99.988% availability of the data via direct feed from NOAA's satellites. These include: AT&T's Dedicated Internet Access, which guarantees its customers with service level agreements ("SLAs") 100 percent service availability; Comcast's Ethernet Dedicated Internet service, which guarantees greater than 99.9 percent availability for SLA customers; and Windstream's Ethernet Internet, which promises 99.99 percent uptime to SLA customers.[40] None of the commenters contest these specific points. Their generalized concerns about the reliability of data delivery therefore carry little weight.

In addition, as Ligado has previously explained, reliability is really a factor of the network architecture for a CDS network implementation. Opponents of a terrestrial CDS concept often use the last-mile or single cloud component to suggest a CDS would provide low reliability by using incorrect availability numbers. To suggest low reliability, opponents also incorrectly use a "serial configuration" approach. The serial configuration approach uses single component availability to calculate availability for the entire system—but such an approach is

[38] *See* Ligado June 13, 2019 *Ex Parte*, Letter from Gerard J. Waldron, Counsel, Ligado Networks LLC to Marlene Dortch, Secretary, Federal Communications Commission, WT Docket 19-116 (June 5, 2019) (hereinafter "Ligado June 5, 2019 *Ex Parte*").

[39] *See* Ligado June 13, 2019 *Ex Parte* at 4.

[40] *See* Ligado June 5, 2019 *Ex Parte* at 2.

not appropriate for high availability system architectures that use redundant components. Instead, appropriate calculations should use a parallel approach.[41]

With respect to concerns over the reliability of the internet's physical infrastructure in inclement weather, commenters conveniently overlook the simple fact that, when weather conditions are severe, the physical components of satellite communications are equally susceptible to disruption as the physical components of internet communications. This fact has not, however, gone unacknowledged by members of the armed services, who have underscored that satellite communications are subject to weather conditions that can have an impact on their effectiveness.[42] Thus, the concept of reliability does not counsel against a CDS, since the same randomness generated by inclement weather that affects internet infrastructure could just as readily affect satellite infrastructure, such as receive stations.

C. Power Levels and Band Plan

Commenters also question the NPRM's proposed power levels for shared use of this band[43] and suggest that one way to limit the effects of shared commercial use would be to

[41] *See generally* Hoda Rohani and Azad Kamali Roosta, *Calculating Total System Availability*, Information Services Organization, KLM-Air France (2014), *available at* https://www.delaat.net/rp/2013-2014/p17/report.pdf.

[42] *See Captain J. W. Rooker*, United States Marines, *Satellite Vulnerabilities EWS Contemporary Issue Paper* (Feb 18, 2008), at 2, *available at* https://apps.dtic.mil/dtic/tr/fulltext/u2/a507952.pdf ("[S]atellite communications . . . are subject to weather, and increasingly vulnerable to attack, and this is dangerous for the nation and its security. . . . Weather effects on satellite communications can be divided roughly into two categories: terrestrial, and extra-terrestrial. Terrestrial effects are those comprised of planetary weather systems, like rain, that affect satellite communications.").

[43] *See, e.g.*, National Spectrum Management Association Comments at 5; OTT Hydromet Corp-Sterling Comments at 1.

allocate the band for uplink use only.[44] These proposals are misguided because they would prevent licensees from using the 1675-1680 MHz spectrum to its maximum potential.[45] As Ligado has explained, both with respect to the power levels and the band plan, the Commission should ensure that the 1675-1680 MHz band mirrors the provisions for the 1670-1675 MHz band. Given the close proximity of the 1675-1680 MHz band and the 1670-1675 MHz band, as well as the lack of a guard band between these two relatively small blocks of spectrum, spectrum coordination will be vital in order to maximize the value of the spectrum to be auctioned. Failing to synchronize the applicable band plans would impose substantial transaction costs, diminishing the utility of the 1675-1680 MHz band.[46]

For this reason, as the Commission finalizes the rules for the 1675-1680 MHz band, it should bear in mind that, with respect to the 1670-1675 MHz band, the Commission adjusted limits related to peak EIRP limits and power level requirements.[47] Maintaining parity between the 1670-1675 MHz and 1675-1680 MHz band would call for applying those same adjustments to the final rules for the 1675-1680 MHz band. The Commission should not take its eyes off the prize of delivering the maximum possible economic benefits from this band. Completing that objective requires extending to the 1675-1680 MHz band the same rules regarding power levels and band plan as exist for the 1670-1675 MHz band.

---

[44] *See, e.g.*, National Spectrum Management Association Comments at 4; AWCIA Comments at 4; Comments of Brian Kopp, WT Docket No. 19-116 (June 21, 2019), at 2 (hereinafter "Kopp Comments").

[45] *See* Ligado Comments at 16.

[46] *See id.* at 15.

[47] *See In the Matter of OP LLC (Crown Castle Int'l Corp.), Licensee of WPYQ831, Petition for Waiver of Section 27.50(f)(1) of the Commission's Rules*, 22 FCC Rcd. 4322, 4322 (2007).

D. Miscellaneous Issues

Commenters have raised other issues with no substantiation, which can be discussed briefly. Some commenters have suggested, without any basis or analysis, that shared commercial use in the 1675-1680 MHz band would disrupt the Emergency Managers Weather Information Network ("EMWIN"), which enables official communications during emergencies.[48] This is a red herring: EMWIN is located 14 megahertz away from the 1675-1680 MHz band—more than far enough to be unaffected by any shared commercial use.

Another commenter suggests that GRB and HRIT services be delivered on alternate spectrum—namely, the C band and K band.[49] This suggestion is obviously outside of the scope of this proceeding (and the Commission's rules and the Administrative Procedure Act) given that these services, too, are not delivered on the 1675-1680 MHz band. In any event, it is not clear this suggestion would address the underlying concerns since, if executed, it likely would require users to buy new or additional equipment, whereas a CDS would be free to all users.

E. NOAA Study

Finally, several commenters suggested the Commission should wait until NOAA has completed its study under the Spectrum Pipeline Act.[50] This appears to be simply an excuse to delay action on the 1675-1680 MHz band, but the Commission can ill afford such delay. This spectrum was first identified for auction in 2013,[51] yet NOAA waited until 2018 to even

---

[48] *See* Harris County Comments at 2; National Hydrologic Warning Council Comments at 3.

[49] *See* Kopp Comments at 4.

[50] *See e.g.*, OTT Hydromet Corp-Sterling Comments at 1; AccuWeather Comments at 7; AWCIA Comments at 7; AGU *et al.* Comments at 1-2.

[51] *See Fiscal Year 2014 Analytical Perspectives, Budget of the U.S. Government*, Office of Management and Budget, at 228-229.

commence the study.[52] As Ligado made clear in its initial comments, tying the future of this band to a study that was only deemed necessary five years after NOAA was first informed the spectrum would be auctioned, is running behind schedule, and has no clear completion date jeopardizes the Commission's ability to meet the fiscal year 2020 deadline the Presidential Budget imposes to complete the auction.[53]

Furthermore, as explained in detail above, the Commission already has the Alion study in the record, and the purpose of that study was to determine the feasibility of a commercial wireless operator sharing the 1675-1680 MHz band with NOAA and the technical and operational parameters under which such operation could occur. That is precisely the issue the Commission raised in the NPRM, and that evidence is already in the record.

It also bears emphasis that many of the topics being analyzed by the NOAA study have already been analyzed by Alion, which is not surprising since Alion conducted its study under the direction of NOAA. Specifically, the Alion study already has weighed in on 6 of the 11 topics the NOAA study is examining: mapping the spacecraft-to-end-user data flows and user needs; analysis of potential interference to downlink sites and assessment of the impact of data loss or latency to end users; protection studies; anomalous propagation interference to critical GOES stations; interference thresholds for Federal GOES-R satellite broadcast receivers; and simulations, passive site surveys, and active test.[54] While the remaining topics the NOAA study is examining may be useful to NOAA for its own internal purposes, they are not relevant to the task before the Commission of determining how this spectrum can be effectively reallocated for

[52] David G. Lubar, STIWG, National Oceanic and Atmospheric Administration, *Spectrum Regulatory Issues* (Mar. 22, 2018), at 8.

[53] *See* Ligado Comments at 8.

[54] *See e.g.*, Alion Report at 17-20, 22-30, 47, 51, 58, 94-111.

shared commercial use. The Alion study already provides the most significant bottom line conclusion: that NOAA's use of GOES-R data can be protected against interference from shared commercial use of 1675-1680 MHz through the creation of protection and coordination zones. Because the Alion study has already been filed, the Commission need not wait for the NOAA study to complete its work.[55]

V. SERVICE RULES SHOULD MAXIMIZE UTILITY OF THE BAND.

In writing the rules for this band, the Commission should strive to maximize the utility of the band for 5G services. Different considerations for the power levels, OOBE limits, and band plan of the 1675-1680 MHz band apply only to the extent these two bands will ultimately *not* be used together as part of a ten megahertz block. In that instance, if the Commission adheres to its proposal to permit downlink-only use (or use in TDD downlink mode), then it should adhere to the precedent set in its AWS-4 Report and Order from 2012 and its H-Block Order from 2013—both of which considered reverse banding for two blocks next to each other.[56]

Consistent with the precedent from those two orders, absent coordination with the licensee of the 1670-1675 MHz band, the Commission should require that the ultimate licensee of the 1675-1680 MHz band adhere to the following requirements:

- ***In-band limit*:** The ultimate licensee's transmit power near towers in the 1670-1675 MHz band must be coordinated on an ongoing basis with the 1670-1675 MHz band licensee[57].

[55] For the same reason, the Commission need not make going through the Commerce Spectrum Management Advisory Committee process a requirement, as proposed by SNRWireless. *See* SNR Comments at 4.

[56] *See In the Matter of Serv. Rules for Advanced Wireless Servs. in the 2000-2020 MHz & 2180-2200 MHz Bands*, 27 FCC Rcd. 16102 (rel. Dec. 17, 2012), at Appendix A, § 27.50, § 27.53; *In the Matter of Service Rules for Advanced Wireless Services H Block—Implementing Section 6401 of the Middle Class Tax Relief and Job Creation Act of 2012 Related to the 1915-1920 MHz and 1995-2000 MHz Bands*, 28 FCC Rcd. 9483 (rel. June 27, 2013), at Appendix A, § 27.50, § 27.53.

[57] Because Ligado leases the 1670-1675 MHz block from Crown Castle, as a practical matter, all such coordination would be with Ligado.

- ***Base or fixed stations*:**
  - The ultimate licensee's stations operating in the 1675-1680 MHz band should be limited to 2000 watts Peak EIRP, except that the total power of any portion of an emission that falls within the 1675-1678 MHz band should not exceed 1 watt. The ultimate licensee may enter into private operator-to-operator agreements with the 1670-1675 MHz licensee to operate at power levels above these limits.
  - If the ultimate licensee operates a base or fixed station in the 1675-1680 MHz band utilizing a power greater than 1 watt EIRP, it must coordinate in advance with the 1670-1675 MHz licensee, which is authorized to operate on adjacent frequency blocks in the 1670-1675 MHz band within 120 kilometers of the base fixed station operating in the 1675-1680 MHz band.
- ***Out of Band Emissions Limits*:**
  - For operations in the 1675-1680 MHz band, the power of any emissions below 1675 MHz should be attenuated below the transmitter power (P) in watts by at least $70 + 10 \log_{10}(P)$ dB.
  - For operations in the 1675-1680 MHz, to the extent a licensee establishes unified operations across the 1670-1680 MHz block, that licensee may choose *not* to observe the above emission limits in a geographic area so long as it complies with other Commission rules and is not adversely affecting operations of other parties by virtue of exceeding the emission limit.
- ***Interference*:** The ultimate licensee should accept any existing and future interference from operations in 1670-1675 MHz.

The AWS-4 and H-Block precedent would also be applicable even if the Commission does decide to permit the 1675-1680 MHz band to be used for uplink (or used in TDD uplink mode) if the adjacent 1670-1675 MHz band is being used for downlink. In that case, consistent with the precedent from those two orders, the Commission should require that the ultimate licensee of the 1675-1680 MHz band adhere to the out of band emissions limits and interference requirements set forth above. In addition, with respect to in-band limits, the transmit power of the 1675-1680 MHz licensee near Ligado's service area in the 1670-1675 MHz band must be coordinated on an ongoing basis.

VI. CONCLUSION

The 1675-1680 MHz band can play a critical role in a larger 40 megahertz spectrum plan that will generate billions of dollars in economic benefit for the United States. As the Commission reviews the comments in this docket, it should stay focused on the overriding

importance of moving 5G forward. The record demonstrates that this important national objective can be achieved while also protecting existing users—both federal and non-federal—in this band. For the reasons set forth herein, the Commission should move swiftly to approve rules to reallocate the 1675-1680 MHz band for shared commercial use that will help achieve the full potential of this band.

Respectfully submitted,

/s/ *Gerard J. Waldron*
Gerard J. Waldron
Ani Gevorkian
COVINGTON & BURLING LLP
One CityCenter
850 Tenth Street, NW
Washington, DC 20001
(202) 662-6000

Counsel for Ligado Networks LLC

Attachments

July 22, 2019

Attachment A

Advancing 5G Deployment: Shared Flexible Use of the 1675 – 1680 MHz Band

PROTECTING NON-FEDERAL USERS THROUGH ALTERNATIVE TECHNOLOGY SOLUTIONS

PREPARED FOR

Ligado Networks LLC

PREPARED BY

Coleman Bazelon

THE Brattle GROUP

July 22, 2019

Notice

- This report was prepared for Ligado Networks LLC, in accordance with The Brattle Group's engagement terms, and is intended to be read and used as a whole and not in parts.
- The report reflects the analyses and opinions of the authors and does not necessarily reflect those of The Brattle Group's clients or other consultants.
- There are no third party beneficiaries with respect to this report, and The Brattle Group does not accept any liability to any third party in respect of the contents of this report or any actions taken or decisions made as a consequence of the information set forth herein.

Table of Contents

I. Introduction

On May 9, 2019, the Federal Communication Commission (FCC) adopted a Notice of Proposed Rulemaking (NPRM) and Order that proposed sharing in the 1675 – 1680 MHz spectrum band between incumbent federal users and terrestrial mobile and fixed wireless services, on a co-primary basis.[1] The NPRM proposes that the band be auctioned for the use of fixed and mobile terrestrial services.[2] However, the NPRM does not propose any change to the federal allocations in the band.[3] Any new fixed or mobile service will have to protect federal incumbents from interference.[4] MetSat Services will continue to operate in the band until at least 2036.[5] While federal operations MetSat Service (space-to-earth) will "remain primary in this band", and NOAA operations will be protected, the FCC proposes that the unused non-federal MetAids Service allocation should be removed from the band.[6] Nonfederal users of the MetSat service, such as state, local and tribal governments and other private entities, are not protected.[7]

This report highlights three important areas of current debate related to the shared and flexible use of this spectrum band. First, it discusses the need for mid-band spectrum in the deployment of 5G services, and how the 1675 – 1680 MHz band is an important part of the solution. Second, it considers the effective measures that ensure that the NOAA federal weather services are protected from interference from terrestrial mobile use. Third, it evaluates the public interest benefits of

1 FCC, "Allocation and Service Rules for the 1675-1680 MHz Band," Notice of Proposed Rulemaking and Order, WT Docket No. 19-116, Adopted May 9, 2019, https://docs.fcc.gov/public/attachments/FCC-19-43A1.pdf, ("NOAA NPRM").

2 *Id.* ¶13.

3 *Id.* ¶14.

4 *Id.* ¶14.

5 *Id.* ¶16.

6 *Id.* ¶14.

7 *Id.* fn 4.

having non-federal users receive the MetSat data through the use of content delivery networks (CDN)[8] instead of direct reception from the NOAA satellites, the GOES-N and GOES-R Series.[9]

II. The Critical Importance of Mid-Band Spectrum in 5G Deployment

Spectrum continues to be a critical resource in the telecommunications space and its importance is growing exponentially with the advent of 5G, the fifth generation of wireless technology that promises to deliver significantly higher speeds, higher data capacity and lower latency.[10] With 5G enabling an increasing number of connected devices such as smart homes, connected cars, smart watches, smart electricity grids, and remote health monitoring, data use is projected to grow significantly.[11] Chairman Pai recently noted that "Just as making available high-band spectrum for commercial use is critical to the development and deployment of 5G in the United States, so too is opening up mid-band spectrum."[12] Currently, Ericsson estimates there are 8.6 billion IoT (Internet of Things) connections, forecasted to grow to over 22 billion connected devices by 2024.[13] In just one year, between 2017 and 2018, mobile data use has jumped from 12.89 trillion MBs to 28.58 trillion, an increase of 82 percent, and has increased 73 times since 2010.[14] Ericsson estimates that

---

8 Content Deliver Networks (CDNs) and Content Delivery Services (CDS) are used synonymously.

9 FCC, "NOAA NPRM," ¶9, 14, Adopted May 9, 2019.

10 Intel, "The 5G Revolution," accessed July 17, 2019, https://worldin2019.economist.com/transformbusinessesandtheworld.

11 "Ericsson Mobility Report," Ericsson, June 2019, accessed July 17, 2019, https://www.ericsson.com/assets/local/mobility-report/documents/2019/ericsson-mobility-report-june-2019.pdf

12 Statement of Chairman Ajit Pai, "Transforming the 2.5 GHz Band," WT Docket No. 18-120, Adopted July 10, 2019, https://docs.fcc.gov/public/attachments/FCC-19-62A2.pdf.

13 Ericsson, "Ericsson Mobility Report: Special edition World Economic Forum," p. 11, January 2019, accessed June 17, 2019, https://www.ericsson.com/assets/local/mobility-report/documents/2019/ericsson-mobility-report-world-economic-forum.pdf.

14 CTIA, "2019 Annual Survey Highlights," https://api.ctia.org/wp-content/uploads/2019/06/2019-Annual-Survey-Highlights-FINAL.pdf.

mobile traffic will grow 3.5 times between 2018 and 2021.[15] The burgeoning data demands from current users and data intensive new uses and the data requirements for the IoT is pushing the boundaries of spectrum use, both in terms of intensity and the bands of spectrum deployed. In an earlier paper, I estimated that by 2019, the US would have a spectrum deficit of 350 megahertz of licensed spectrum.[16] Although technology continues to improve the intensity and efficiency of spectrum use, these will not eliminate the need for additional spectrum.[17]

A successful 5G deployment will require using all available spectrum types and spectrum bands – low, mid and high-bands.[18] Low band spectrum, below 1 GHz, will provide coverage for wide-area and long-range communications, and is ideal for long-range macro deployments, and for connecting the wide-area IoT. Mid-band spectrum will support applications that would benefit from a combination of coverage and capacity support. Millimeter wave (mmW) or high-band spectrum, at 24 GHz and above, will provide capacity for short-range communications that require fast data rates and low latency.[19] This mix of spectrum that 5G networks productively integrate is called the 'spectrum trifecta.'[20]

---

[15] Ericsson, "Ericsson Mobility Report," p. 21, June 2019, accessed July 17, 2019, https://www.ericsson.com/49d1d9/assets/local/mobility-report/documents/2019/ericsson-mobility-report-june-2019.pdf.

[16] Coleman Bazelon and Giulia McHenry, "Substantial Licensed Spectrum Deficit (2015-2019): Updating the FCC's Mobile Data Demand Projections," CTIA, June 13, 2015, accessed July 14, 2019, https://brattlefiles.blob.core.windows.net/files/5927_substantial_licensed_spectrum_deficit_(2015-2019)_-_updating_the_fcc's_mobile_data_demand_projections.pdf.

[17] 5G Americas, "Spectrum Landscape for Mobile Services," p. 3, November 2017, accessed June 30, 2019, http://www.5gamericas.org/files/8415/1018/3549/5G_Americas_Whitepaper_Spectrum_Landscape_For_Mobile_Services.pdf.

[18] Coleman Bazelon, "The Next Wave of Spectrum Reallocation: The Value of Additional Mid-Band Spectrum Reallocations," Prepared for the CTIA, pp. 11, November, 2017, https://docs.house.gov/meetings/IF/IF16/20171116/106636/HHRG-115-IF16-20171116-SD005-U5.pdf.

[19] Letter to Marlene H. Dortch, FCC, from Reed Hundt, "Re: Use of Spectrum Bands Above 24 GHz for Mobile Radio Services," GN Docket No. 14-177, July 1, 2016, https://ecfsapi.fcc.gov/file/1070164539932/Hundt%20Letter%20on%205G%20(7-1-2016).pdf. *See also*, Tom Wheeler, "The Future of Wireless: A Vision for U.S. Leadership in a 5G World," prepared remarks at the National Press Club, Washington, D.C., June 20, 2016, http://transition.fcc.gov/Daily_Releases/Daily_Business/2016/db0620/DOC-339920A1.pdf.

[20] The term "spectrum trifecta" was coined by FCC Chairman Tom Wheeler in his June 20th, 2016 remarks at the National Press Club. Tom Wheeler, "The Future of Wireless: A Vision for U.S. Leadership in a 5G World," prepared remarks at the National Press Club, Washington, D.C., June 20, 2016, accessed July 10, 2019, http://transition.fcc.gov/Daily_Releases/Daily_Business/2016/db0620/DOC-339920A1.pdf.

The focus of unmet need for 5G is most immediately on the mid-band frequencies.[21] Until a couple of years ago, all spectrum currently allocated to mobile wireless networks was concentrated in the below 1 GHz band and around the 2 GHz band.[22] Spectrum above about 3 GHz was not seen as viable to deploy in mobile networks. One of the innovations of 5G is to more adeptly utilize frequencies to leverage their inherent advantages, and economically deploy mid-band and higher frequencies for mobile wireless.[23] In the 'spectrum trifecta' of low-, mid-, and high-bands, mid-band spectrum in particular is seen as a "sweet spot" as it combines both capabilities of the low-band and the high-band spectrum, combining moderate bandwidth and coverage with mobility.[24] With most low band spectrum already allocated to commercial mobile uses and significant amounts of high-band coming on line in the near future, carriers are focused on additional mid-band frequencies to meet the growing demands of 5G networks.

The FCC has made the availability of 5G-capable spectrum a priority, as outlined in their strategy Facilitate America's Superiority in 5G Technology (the 5G FAST Plan).[25] The FCC concluded its second high-band 5G airwave auction in May 2019, selling spectrum in the 24 GHz and 28 GHz bands for approximately $2.7 billion during the first two mmW auctions.[26] Later this year, the FCC plans to auction 5G bands in 37 GHz, 39 GHz, and 47 GHz bands, totaling 3,400 megahertz, the largest ever spectrum auction in the United States in terms of raw megahertz.[27]

---

21 Roslyn Layton, "Mid Band Spectrum Is the Next Critical Piece to Timely 5G Deployment," Forbes, May 1, 2019, accessed July 17, 2019, https://www.forbes.com/sites/roslynlayton/2019/05/01/mid-band-spectrum-is-the-next-critical-piece-to-timely-5g-deployment/#6bf2ac481922.

22 Jessica Rosenworcel, "Choosing the Wring Lane in the Race to 5G," Wired, June 10, 2019, accessed July 17, 2019, https://www.wired.com/story/choosing-the-wrong-lane-in-the-race-to-5g/.

23 FCC, "The FCC's 5G FAST Plan," accessed March 17, 2019, https://www.fcc.gov/5G. *See also*, Coleman Bazelon, "The Next Wave of Spectrum Reallocation: The Value of Additional Mid-Band Spectrum Reallocations," Prepared for the CTIA, p. 11, November, 2017, https://docs.house.gov/meetings/IF/IF16/20171116/106636/HHRG-115-IF16-20171116-SD005-U5.pdf.

24 Bret Swanson, "The Spectrum Sweet Spot: How Mid-Band Waves Will Help Power 5G Wireless," AEI, June 29, 2018, http://www.aei.org/publication/the-spectrum-sweet-spot-how-mid-band-waves-will-help-power-5g-wireless/.

25 FCC, "The FCC's 5G FAST Plan," accessed June 21, 2019, https://www.fcc.gov/5G.

26 FCC, "FCC Concludes First High-Band 5G Airwaves Auctions," May 28, 2019, accessed June 21, 2019, https://docs.fcc.gov/public/attachments/DOC-357702A1.pdf.

27 In the Upper 37 GHz and the 39 GHz bands a total of 2,400 megahertz will be auctioned. Another 1,000 megahertz will come from the 47 GHz band. See FCC, "Incentive Auction of Upper Microwave Flexible Use Service Licenses in the Upper 37, 39, and 47 GHz Bands for Next-Generation Wireless Services;

In line with this vision of making more spectrum available for 5G, Ligado asks the FCC to make 40 megahertz of mid-band spectrum available for terrestrial mobile use.[28] In this valuable mid-band space, Ligado currently holds 20 megahertz of terrestrial downlink spectrum in the 1525 – 1559 MHz band, 20 megahertz of terrestrial uplink spectrum in the 1626.5 – 1660.5 MHz band, and has leased the rights to 5 megahertz of spectrum in the 1670 – 1675 MHz band held by Crown Castle International Corporation ("Crown Castle").[29] Of this, Ligado has committed to surrendering terrestrial rights to 10 megahertz of downlink spectrum (1545 – 1555 MHz) to protect Global Navigation Satellite Systems (GNSS) such as GPS.[30] This leaves Ligado with 35 megahertz spectrum in the mid-band. This could be significantly boosted with a valuable complementary asset if the firm can plan to couple the 5 megahertz in the NOAA band with its existing 35 megahertz. Ligado could then support its own 5G deployment on a national basis. Commissioner Brendan Carr has publicly stated that "combined with adjacent and nearby channels we could have a 40 megahertz block that offers high throughput at great distance and those are excellent characteristics for next-gen mobile broadband."[31]

Procedures for Auction 103," ¶ 6, adopted July 10, 2019, accessed July 17, 2019, https://docs.fcc.gov/public/attachments/FCC-19-63A1.pdf.

28 Ligado Networks, "Commission Action Can Unlock 40 Megahertz of Mid-Band Spectrum," Ex Parte Presentation in IB Docket No. 11-109, p. 2, June 5, 2017, https://ecfsapi.fcc.gov/file/1060526183070/Ligado%20Ex%20Parte%20and%20Summation%20Document%20--%20June%205%2C%202017.pdf.

29 To protect GPS operators Ligado has offered to give up its terrestrial use authority in the 1545-1555 MHz band, thus creating a 23 megahertz guardband for GPS. Additionally, it has applied for "reduced power levels nationwide for base stations that would operate in the 1526-1536 MHz band (under Ligado's proposal, the "lower downlink" band) and for user equipment in the 1627.5-1637.5 MHz and 1646.5-1656.5 MHz portions of the band (the "lower uplink" and "upper uplink" bands, respectively). *See* Ligado Networks, "Commission Action Can Unlock 40 Megahertz of Mid-Band Spectrum," Ex Parte presentation in IB Docket No. 11-109, pp. 3 - 4, June 5, 2017, https://ecfsapi.fcc.gov/file/1060526183070/Ligado%20Ex%20Parte%20and%20Summation%20Document%20--%20June%205%2C%202017.pdf. *See also,* Coleman Bazelon, "Putting Mid-Band Spectrum to Work: Sharing between Ligado and its GPS Neighbors", p. 6. Comments of Ligado Networks LLC, IB Docket No. 11-109 May 23, 2016, http://licensing.fcc.gov/myibfs/download.do?attachment_key=1136780.

30 Ligado Networks, "Ligado Network's Mobile Terrestrial Services Plan & the Protection of GNSS Service," pp. 8-9, November 15, 2017, accessed June 6, 2019, https://www.gps.gov/governance/advisory/meetings/2017-11/green.pdf.

31 Randy Sukow, "1675-1680 MHz Item Turns into Debate on Mid-band Readiness," May 9, 2019, accessed July 10, 2019, https://www.nrtc.coop/rural-connect/1675-1680-mhz-item-turns-into-debate-on-mid-band-readiness.

Such a nationwide 5G network can only be viable if the 14 current federal protection zones are not expanded to encompass non-federal users. [32] The FCC recognizes that such protection zones "may limit a non-federal fixed or mobile licensee's ability to serve some portion of the population."[33] Boeing has stated that "any protection zones that are designed to prevent harmful interference to satellite reception may need to be substantial in size."[34] A government study estimates the radius of protection zones for NOAA satellites (GOES) is as large as 98 kilometers.[35] Thus given such large radii of these protection zones, another 100 – 200 protection zones will cause significant impairment and make it less usable for the deployment of 5G.[36] However, Ligado has committed to ensuring these users continue to have access to the meteorological information they now receive through the MetSat Service. [37] Thus, imposing only the minimal amount of impairment required to protect federal users will be in the public interest and will maximize the value of this band.

Mid-band spectrum is immensely valuable to 5G deployment and to the U.S. economy. For example, a recent CTIA report estimates that 400 megahertz of licensed mid-band spectrum

---

32 FCC, "NOAA NPRM", Appendix A, Adopted May 9, 2019.

33 *Id.* ¶ 35.

34 Boeing Company Comments on "NOAA NPRM," p. 4, WT Docket No. 19-116, June 21, 2019, https://ecfsapi.fcc.gov/file/1062160300801/Boeing%20Comments%20on%201675%20MHz%20band%20NPRM%206%2021%202019.pdf.

35 The radii range from 2 – 98 kilometers. *See* Pouyan Amirshahi, and Steven Grippando, "Radio Frequency Interference Monitoring System for Weather Satellite Ground Stations: Challenges and Opportunities," p. 18, 2017, Radio Frequency Interference Monitoring System, Office of Satellite Ground Services, https://dyspan2017.ieee-dyspan.org/sites/dyspan2017.ieee-dyspan.org/files/u49/DySpan_presentation_v2_Amirshahi.pdf.

36 Ligado estimates that there are approximately 100 unregistered non-federal users, while the FCC puts the number at twice that. *See* Comments of Ligado Networks on "NOAA NPRM", pp. 7-8, WT Docket No. 19-116, June 21, 2019. ("Comments of Ligado Networks on NOAA NPRM"), https://ecfsapi.fcc.gov/file/10621258324775/Ligado%20Comments%20on%201675-1680%20MHz%20NPRM%20%5B6.21.19%5D.pdf.

37 Coleman Bazelon, "Choosing an Appropriate Geographic License Size," pp. 4-5, Prepared for Ligado, Filed as a part of Ligado's Comments on the "NOAA NPRM", WT Docket No. 19-116, June 21, 2019, accessed July 17, 2019, https://ecfsapi.fcc.gov/file/10621258324775/Ligado%20Comments%20on%201675-1680%20MHz%20NPRM%20%5B6.21.19%5D.pdf.

between 3.45 GHz and 4.2 GHz, can add over $270 billion in additional GDP to the U.S. economy.[38] To understand the magnitude of the impact of spectrum availability on the U.S. economy, my earlier research shows that in 2015 the 645.5 megahertz of licensed spectrum available for the mobile wireless industry is valued at approximately $500 billion.[39] The indirect impact, through a multiplier analysis implies that this spectrum also generates between $5 trillion and $10 trillion in consumer surplus, a 10 to 20 times multiple of its direct value.[40] Therefore, this 5 megahertz of mid-band spectrum has the potential to add a significant amount of value to the U.S. economy. A government estimate values this spectrum at $600 million.[41] This implies, based on past experience, consumer surplus generated on the order of $6 – $12 billion for the economy.[42]

III. Shared Flexible Use in the 1675 – 1680 MHz Band Does Not Harm NOAA

The NPRM has been very clear in stating that all federal operations in the band are protected. Hence all NOAA operations in the band, such as the collection and transmission of weather data through its GOES operations, will be protected even when terrestrial mobile users are given co-primary status, and the FCC has identified protection zones that will safeguard NOAA's operations.[43] As stated by Ligado in its Comments on the 1675 – 1680 MHz NPRM, "the commercial licensee of this spectrum should be obligated to successfully coordinate base station

---

38 David W. Sosa and Greg Rafert, "The Economic Impacts of Reallocating Mid-Band Spectrum to 5G in the United States," CTIA Report, April 2019, https://api.ctia.org/wp-content/uploads/2019/02/The-Economic-Impacts-of-Reallocating-Mid-Band-Spectrum-to-5G-1.pdf.

39 Coleman Bazelon and Giulia McHenry, "Mobile Broadband Spectrum: A Vital Resource for the U.S. Economy,' Prepared for CTIA, p. 1, May 11, 2015, https://api.ctia.org/docs/default-source/default-document-library/brattle_spectrum_051115.pdf

40 *Id.* p. 24.

41 Mike Dano, "Ligado's 5G Ambitions Take One (Tiny) Step Forward," April 18, 2019, https://www.lightreading.com/mobile/5g/ligados-5g-ambitions-take-one-(tiny)-step-forward/d/d-id/750924.

42 Calculation: $600,000,000 x 10 = $6 billion.

Calculation: $600,000,000 x 20 = $12 billion.

43 FCC, "NOAA NPRM," ¶¶ 8 – 9, Adopted May 9, 2019.

operations with Federal Government entities operating meteorological satellite earth station receivers within the 14 protection zones currently set forth in note US88 of the U.S. Table of Allocations ("U.S. Table"), including the radius for each such protection zone."[44]

In addition, Ligado recognizes that some federal earth stations may need to be built in the future. In order to plan for protection zones for these, Ligado has urged the Commission to finalize such plans before the auction date.[45] Such an approach would give the federal users flexibility to add new sites in the future, while giving the auction participants some certainty about where these stations would be located and the impairments around them.

IV.A Content Delivery Network (CDN) is in the Public Interest

With authorized federal users fully protected by exclusion zones, as early as 2016, Ligado had proposed a Content Delivery Network (CDN) to allow all other current and future users of the NOAA weather data from the GOES-N and GOES-R satellites to continue to receive the data streams currently available.[46] By deploying a CDN, Ligado proposes replacing satellite delivery of the data with internet broadband based delivery of the same data.[47] Doing so is unequivocally in the public interest.

One way of evaluating the merits of a CDN for non-protected users of NOAA's weather data requires weighing any costs to current or future users with the benefits of the additional spectrum made available by deploying the CDN against creating additional exclusion zones around 100 to

---

44 "Comments of Ligado Networks on NOAA NPRM," p. 6, June 21, 2019.

45 *Id.* p. 7.

46 Reply Comments of Ligado Networks on "Comment Sought to Update the Record on Ligado's Request That the Commission Initiate A Rulemaking to Allocate the 1675-1680 MHz Band For Terrestrial Mobile Use Shared With Federal Use," RM-11681, August 11, 2016, accessed July 17, 2018, https://ecfsapi.fcc.gov/file/10812237330359/Ligado%20Reply%20Comments%20--%20RM-11681%20(August%2011%2C%202016).pdf

47 "Comments of Ligado Networks on NOAA NPRM," p. 10, June 21, 2019.

200 satellite receive sites.[48] Evaluating this trade-off is an application of The Principle of Spectrum Reallocation that says that a band of spectrum should be reallocated from its current use to a new use if the benefits created in the new use exceed the costs of making the spectrum available to reallocate.[49] In this case, the benefits in the new use, as discussed above, are making 5 MHz of nationwide spectrum available that will create significant value when paired with the adjacent 5 MHz and will help facilitate putting 40 megahertz of mid-band spectrum to productive use. The costs of making it available are the net costs of the transition to a CDN for current and future users of the satellite-received weather data. As discussed below, The Principle of Spectrum Reallocation strongly favors reallocating this band and the significant value created clearly benefits the public interest.

As noted above, making the 5 megahertz of the 1675 – 1680 MHz band available throughout almost all of the U.S. will create significant value, measured in the billions of dollars. On its own, the 5 megahertz will likely raise hundreds of million in bids. A government study estimates the value of this 5 megahertz at $600 million.[50] When combined with the adjacent 5 megahertz controlled by Ligado it will be worth significantly more.[51] Moreover, as it supports Ligado's deployment of 40 megahertz for 5G services, the value created from this band is leveraged further.

The net costs of current and future users have three components. As a preliminary matter, however, the cost of current satellite receive equipment, much less the total value of the GOES system cited by some respondents, are not relevant quantities in evaluating the merits of repurposing this spectrum.[52] These investments are sunk and exist at the same levels whether or

---

48 *Id.* pp. 7-8.

49 Coleman Bazelon, "Principle of Spectrum Reallocation," Oral Testimony of Coleman Bazelon, The Brattle Group, Inc. U.S. House of Representatives, Committee on Energy and Commerce Subcommittee on Communication and Technology, pp. 1 – 2, April 12, 2011, https://brattlefiles.blob.core.windows.net/files/8123_oral_testimony_of_coleman_bazelon_apr_12_2011.pdf

50 Mike Dano, "Ligado's 5G Ambitions Take One (Tiny) Step Forward," April 18, 2019, https://www.lightreading.com/mobile/5g/ligados-5g-ambitions-take-one-(tiny)-step-forward/d/d-id/750924.

51 "Comments of Ligado Networks on NOAA NPRM," pp. 13-14, June 21, 2019.

52 Accuweather states, "In total, the GOES-R program budget is $10.8 billion." See Comments on the "NOAA NPRM," WT Docket No. 19-116, Accuweather, p. 16. June 21, 2019, https://ecfsapi.fcc.gov/file/1062173865405/AccuWeather_Comments_WT_Docket19_116.pdf. *See also,*

not the spectrum is repurposed. To argue that these investments suggest the CDN should not be employed and that instead exclusion zones for these users should be created to preserve these investments is an example of the sunk cost fallacy.[53]

A CDN will influence the costs of current and future users of the NOAA weather data in three ways.

- First, there may be potential savings in future satellite earth station costs. All future users, as well as current users who need to replace or upgrade their current equipment, will save on the costs of having to invest in satellite earth stations. That is, they will be able to avoid making significant sunk investments. These costs have been estimated to exceed $100,000 per earth station.[54]

- Second, they may incur some additional costs for broadband connectivity. The early experience with George Mason University and University of Oklahoma suggest that there are virtually no additional costs when connecting to Ligado's CDN.[55] If a user's broadband internet connection was not sufficiently robust or if they wanted to add additional redundancy, then some cost may be incurred. It is unclear, however, if such upgrade costs are really caused by converting to a CDN as opposed to existing as a pre-existing need of

---

American Weather and Climate Industry Association, Comments on the "NOAA NPRM," WT Docket No. 19-116, p. 5, June 20, 2019, https://regmedia.co.uk/2019/06/25/fcc-awcia.pdf

Lockheed Martin states, "The investment to date in satellite hardware and software to support GRB is over $10 million per spacecraft." See Lockheed Martin, Comments on the "NOAA NPRM," WT Docket No. 19-116, p. 2. June 21, 2019, https://ecfsapi.fcc.gov/file/106210337421908/LM%20Draft%20Comments%20WTB%20Docket%2019-116%20FILED.pdf

53 Basic economics principle dictates that sunk costs should not be an element in decision making, and decisions should always be at the margin, implying that they should be based on the incremental cost versus incremental benefits of a decision. The sunk cost fallacy happens when one bases a decision on costs that have already been incurred and are 'sunk'. In the current matter, the decision should be based on the incremental costs and not on the total cost of the GOES satellite system or earth stations that have already been incurred. *See* John S. Hammond, Ralph L. Keeney, and Howard Raiffa, "The Hidden Traps in Decision Making." p. 5, Harvard Business Review, 1998, https://ucilnica.fri.uni-lj.si/pluginfile.php/97648/mod_resource/content/1/Hidden_Traps_in_Decision-Making.pdf.

54 "Comments of Ligado Networks on NOAA NPRM," p. 11, June 21, 2019.

55 Ligado Networks Ex Parte, WT. Docket No. 19-116, p. 4, June 13, 2019. https://ecfsapi.fcc.gov/file/10613188522839/Ligado%20Ex%20Parte%206.13.19%20%5BAS%20FILED%5D.pdf.

the data users. Any institution that claims to need such reliable access to the data that they would want to upgrade their broadband internet connection would likely need such an upgrade to get their processed information out from their institution to a larger community. That is, any user that needs a high level of reliability to get the data in to their institution likely has the same need for reliability to get the information they develop with the NOAA data out of their institution. However, due to NOAA's Big Data Project, all of the real-time GOES-R data is available on Amazon Web Services.[56] This has the advantage of using the cloud to directly analyze the data "without requiring further distribution."[57] This potentially implies that a gigabit speed connection should be sufficient. An independent wired broadband connection that can handle symmetric upload and download speeds of 1 Gigabit can be obtained for approximately $70 - $140 per month, with most services offered around $90-$100 per month.[58] Thus the lifetime costs of this connectivity are measured at most in the thousands of dollars for an individual connection and under 5 million dollars for all non-federal users.[59]

---

[56] Steve Ansari et. al, "Unlocking the Potential of NEXRAD Data through NOAA's Big Data Partnership," American Meteorological Society, January, 2018, accessed July 17, 2019, https://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-16-0021.1.

[57] Amazon Web Services, "Accessing NOAA's GOES-R Series Satellite Weather Imagery Data on AWS," August 3, 2017, accessed July 17, 2019, https://aws.amazon.com/blogs/publicsector/accessing-noaas-goes-r-series-satellite-weather-imagery-data-on-aws/.

[58] Eric Liston, "A Complete List of All Gigabit Internet Services Providers (ISPs) in the USA – 19+ ISPs", July 29, 2018, accessed July 11, 2019, https://flixed.io/top-gigabit-isps-usa/. *See also*, USI Fiber Internet, "Plans and Prices," accessed July 11, 2019, https://fiber.usinternet.com/plans-and-prices/. Currently there are no Gigabit speeds offered for residential satellite services. One of the highest is offered by Viasat with 100 Mbps of download speed at $150 per month. *See* Mindy Woodall, "Best Satellite Internet Providers of 2019", November 19, 2018, accessed July 11, 2019, https://www.reviews.org/internet-service/best-satellite-internet-providers/.

[59] Suppose we assume a discount rate between 3 and 7 percent and a 20 year connection and $100 per month ($1200 annually), the lifetime cost of this connection is approximately $12,000 to $18,000. Lifetime Cost = (1200 / 0.03) x (1 – 1 / ((1.03) ^ 20)) or (1200 / 0.07) x (1 – 1 / ((1.07) ^ 20)). The lifetime cost is calculated as the present value of a series of constant future periodic nominal costs ($1200 per year in this case). This is similar to the calculation of an annuity payment. Assuming that there are 250 non-federal users, this cost is only around $3 - $4.5 million. The cost will probably be lower than this, as connection costs are declining rapidly. I use a 7 percent discount rate based on OMB's guidance on Regulatory Impact Analysis. *See* Office of Information and Regulatory Affairs, "Regulatory Impact Analysis: A Primer," p. 11, E.O. 13422, Circular A-4, August 15, 2011, https://www.nap.edu/read/11534/chapter/10#298.

- Third, there may be potential costs from changes in latency. Commenters have argued that switching from satellites to a CDN will increase latency in receiving the data.[60] While it is a technical matter that determines the acceptable level of latency for certain kinds of service, and thus beyond the scope of this paper, I note two important economic points. First, any costs from increased latency can be priced, but none of the commentators have put such a price on it. Second, the decision variable should be a change in latency when characterizing the effect of the change from satellite to a CDN, not the total value created by the data. This difference in latency should be the relevant comparison metric when valuing the increased latency and not the absolute amount of latency when using the CDN.

Proposals to provide the same exclusion zone protections afforded the protected government users to all current users receiving the NOAA weather data directly would severely diminish the value of the 1675 MHz – 1680 MHz band.[61] This is because the protected zones that could not be used by new terrestrial users would expand from 14 to between 100 and 200.[62] Such fragmentation of the band would diminish the usable spectrum and greatly increase the coordination costs required to deploy spectrum around the exclusion zones. Consequently, the lost benefits from these proposals would be measured in billions of dollars.

Offset against the billions of dollars in benefits from reallocation, the net costs to current and future users are small. As noted above, the savings in future satellite earth station investments exceeds $100,000 per earth station. Any added costs for broadband connectivity, even if caused by the use of a CDN, are at most a few million. Although the unregistered users of the NOAA weather data provide value added services, they have not established what the economic value is of any change in latency in receiving the data. Surely timely weather related data is important, just as surely differences in timeliness measured in seconds, at best, cannot have large economic costs, if any costs at all.

---

[60] Reply Comment of Space Science and Engineering Center (SSEC) on the "NOAA NPRM," p. 3, WT Docket No. 19-116, June 27, 2019. https://ecfsapi.fcc.gov/file/10627235269351/SSEC%20to%20FCC%20Reply%20WT%20Docket%20No%2019-116%2027%20June%202019%20Signed.pdf. Comments of Accuweather on the "NOAA NPRM," p. 14, June 21, 2019, https://ecfsapi.fcc.gov/file/1062173865405/AccuWeather_Comments_WT_Docket19_116.pdf.

[61] Comments of Accuweather on "NOAA NPRM," pp. 5, 13, 19. WT Docket No. 19-116. https://ecfsapi.fcc.gov/file/1062173865405/AccuWeather_Comments_WT_Docket19_116.pdf.

[62] "Comments of Ligado Networks on NOAA NPRM," p. 7, June 21, 2019.

Taken together, savings in satellite earth station investments, possible increases in broadband connectivity, and small increases in latency of receiving data are surely relatively small costs compared to the billions of dollars in benefits created by replacing satellite transmission of the NOAA weather data to unregistered users with broadband internet delivery through a CDN. Consequently, the Principle of Spectrum Reallocation suggests making this spectrum available through the migration to a CDN will be beneficial to society and serve the public interest.

BOSTON
NEW YORK
SAN FRANCISCO
WASHINGTON
TORONTO
LONDON
MADRID
ROME
SYDNEY

THE Brattle GROUP

Attachment B

DECLARATION OF GEOFFREY STEARN

1. My name is Geoffrey Stearn. I am an independent telecommunications consultant and advisor. From July 2010 to February 2019, I worked for Ligado Networks LLC ("Ligado"), most recently as Senior Vice President - Strategic Initiatives, and I still work closely with the company in a consulting role. During my time at Ligado, I was involved in the company's joint efforts with the National Oceanic and Atmospheric Administration ("NOAA") to oversee a study conducted by Alion Science and Technology Corporation ("Alion") on protection zones in the 1670-1680 MHz band. I have over 30 years of experience in the wireless communications industry. I hold a B.A. from the University of Maryland and an M.B.A. from The George Washington University.

2. Ligado's initial high-level discussions with NOAA about spectrum sharing began in April 2012, when Doug Smith, Ligado's President and Chief Executive Officer, and I met with Joe Klimavicz, who was NOAA's Chief Information Officer. At the time, NOAA was concerned about interference between radiosondes and GOES-R and was interested in relocating radiosondes out of the 1675-1683 MHz band. In October 2012, during a meeting with NOAA staff and contractors including David Franc, Ivan Navarro, Mark Mulholland, Beau Backus and Glenn Tallia, Ligado discussed the possibility of commissioning a study on spectrum sharing and radiosonde relocation. More serious discussions on this topic began in early 2013, at which time Ligado spoke with NOAA about the logistics related to funding a spectrum sharing study that would analyze the technical feasibility of shared commercial and federal use of the 1675-1680 MHz band and the relocation of radiosondes to the 401-403 MHz band.

3. Initially, Ligado offered to pay the costs for NOAA to conduct its own spectrum sharing study, but Glenn Talia, a NOAA attorney, subsequently notified Ligado in the Spring of 2013 that a direct reimbursement to NOAA by Ligado would not be a viable option. Ligado, James Mentzer, David Franc (both of NOAA's Radio Frequency Management Division) and Glenn Tallia ultimately agreed that Ligado would commission a spectrum sharing study to be conducted by a third party that NOAA would endorse. This NOAA group suggested that Ligado hire Alion to conduct the spectrum sharing study, based at least in part on previous work that Alion had performed related to GOES-R. As a result of this recommendation, Ligado contracted with Alion on June 28, 2013 to conduct a spectrum sharing study.

4. The first meeting to commence the study took place on July 1, 2013 at NOAA headquarters in Silver Spring, Maryland. Attendees at the meeting at NOAA offices included representatives from Alion, NOAA and Ligado. Even though Ligado was funding the spectrum sharing study, NOAA was centrally involved from the beginning of the process to define the nature and scope of the spectrum sharing study. For example, NOAA representatives, including David Franc, Ivan Navarro and Glenn Talia, participated in drafting the Statement of Work. In addition, these same NOAA representatives and others including James Mentzer, Carmelo Rivera, Mark Mulholland, Beau Backus and Jason Kim, among others, joined the planning calls, and most of them actively participated in the ongoing meetings with Alion. All in-person meetings took place either at Alion's facility in Annapolis Junction, Maryland or at NOAA headquarters in Silver Spring, Maryland. Throughout the course of the study, NOAA provided a considerable amount of direction and data to Alion and, along with Ligado, provided input on the draft reports that Alion shared with both parties.

5. As Ligado's lead on the spectrum study, I generally deferred to NOAA in making final decisions regarding specific parameters within the study. For instance, in the Task 2 report, one particular value in the model that determined the size of the protection zones was a probability factor. At the time of the study, the Commerce Spectrum Management Advisory Committee ("CSMAC") was working on an AWS-3 study in which the probability was set at 50%. I suggested that, given the similarity between the analyses, the Alion study should use the same factor of 50%, but NOAA insisted on a .025% factor. I discussed this lower figure with my colleagues at Ligado, including Doug Smith, Ligado's CEO, as well as Maqbool Aliani who leads Ligado's RF engineering group, since we were aware that this significantly lower figure would result in a much less favorable outcome for Ligado. After obtaining internal company consensus, as Ligado's representative I reluctantly agreed to this change so that NOAA would continue to support the spectrum sharing study and so that the study could be completed expeditiously.

6. Alion's final spectrum sharing reports were published in several phases. The first report ("Task 1 Report") was complete in January 2014, and Ligado filed it with the FCC that same month. This report assessed the feasibility of relocating NOAA radiosondes outside of the 1675-1680 MHz band and concluded that such relocation would be feasible. The second report, which was finished in February 2014, delineated appropriate coordination zones around the then-current GOES satellites (GOES 13-15). At NOAA's behest and with Ligado's concurrence, Alion also prepared a supplement to the second report, which focused primarily on GOES-R ground locations and was finished in April 2014. This addition resulted in an increase in Alion's fee, which was paid by Ligado, as well as an extension of time to complete the study. Ligado filed the second report and supplement ("Task 2 Reports") with the FCC on April 14, 2014.

Together, the Task 1 and Task 2 Reports demonstrated the feasibility of relocating NOAA radiosondes from the 1675-1680 MHz band and that shared use of that band by a commercial terrestrial wireless operator would be feasible while still protecting NOAA earth stations.

7. During my observations of meetings, emails, and phone calls over the entire course of this period, it was clear that NOAA staff and contractors, including James Mentzer, David Franc, Ivan Navarro, Mark Mulholland, Craig Keeler and Beau Backus, actively participated in defining the scope of the spectrum sharing study, and they also were integrally involved in the management of Alion during their work on the spectrum sharing study. This effort involved providing key input in the drafting of the final report. For instance, Ivan Navarro provided substantive comments to Alion on an early draft of the Task 2 report on February 5, 2014—which is just one example of the significant input received from NOAA stakeholders throughout this process. Additionally, NOAA was clear regarding its participation in the study, with David Franc specifically requesting by email on January 7, 2014 that a statement for a news article summarizing Task 1 be revised "to indicate that NOAA was involved with [the] process from the start." Once the full study was complete, NOAA itself filed the Alion reports with NTIA.

8. Based on my experience working on this project with NOAA and Alion in 2013 and 2014, it was evident to me that this study, including its scope, methodology and conclusions, had the full endorsement of NOAA and its staff who participated in this work. I understand that NOAA may disagree with spectrum sharing as a concept, but I believe that their endorsement of the Alion study has not wavered, as I am not aware of any subsequent statements by NOAA personnel that would call into question the conclusions reached in the Alion reports. As the above facts indicate, even though Ligado funded the Alion study, NOAA supported the idea of

the study from the beginning and actively participated in managing the process through its completion.

9. Ligado paid Alion a total of $1,424,370.05 for its work on the spectrum sharing study.

Signed: */s/*
Geoffrey Stearn

Date: July 22, 2019

Attachment C

Delivery of Processed Versus Unprocessed Data